SCRF Status and Future Plans at the Photoinjector

Tim Koeth

Sept, 23rd, 2005

Outline

- Accelerating SCRF
  - Exisiting 9-cell: Cap Cav 1
  - New 9-cell: Cap Cav 2
- Deflecting Mode SCRF Cavity (DMC)
  - Bunch Length Measurement
  - ILC application of DMC as a Crabbing device
- LLRF
  - Algorithm Development
  - Testing at A0
  - Making LLRF studies a permanent fixture
- Time Line

Existing 9-Cell: CapCav 1

Maximum operating gradient: 12MV/m

UPGRADES

- Repair cold tuner
  - i. just replace $100 Sanyo motor
  - ii. Replace Sanyo motor with $4K Phytron Cryo compatable
- Investigate and repair HOM cables

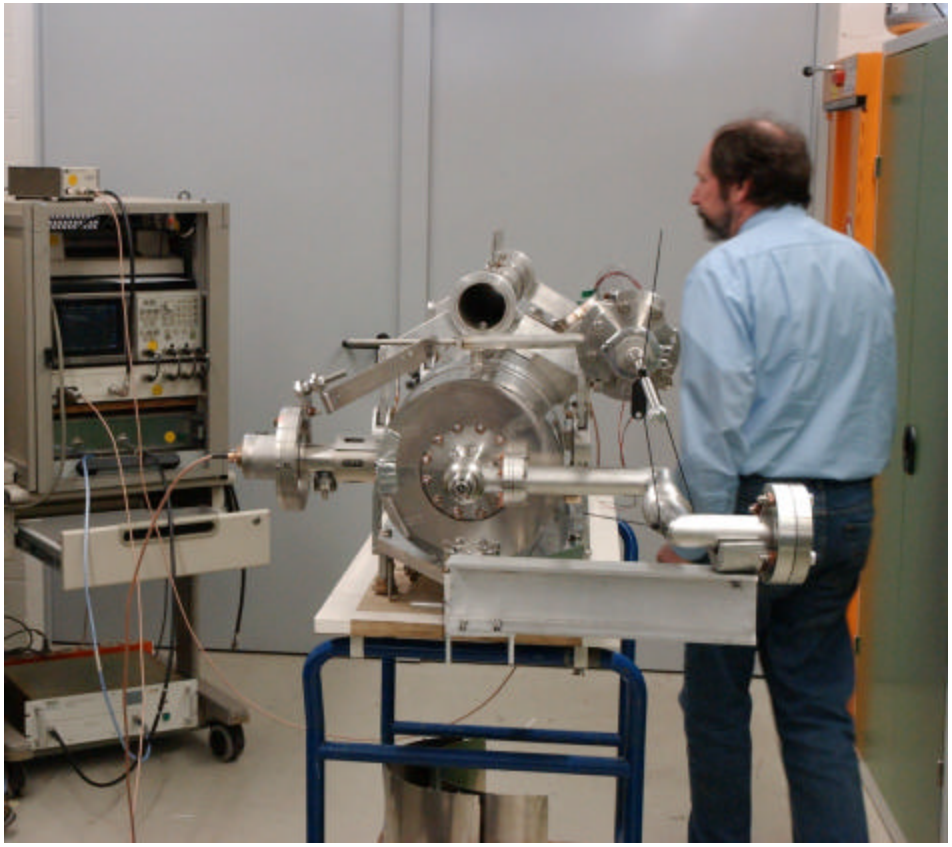
New 9 Cell: Cap Cav 2

Maximum Operating Gradient: 25MV/m

(tested up to 33 MV/m)

High X-ray generation, reasonable though at 25MV/m

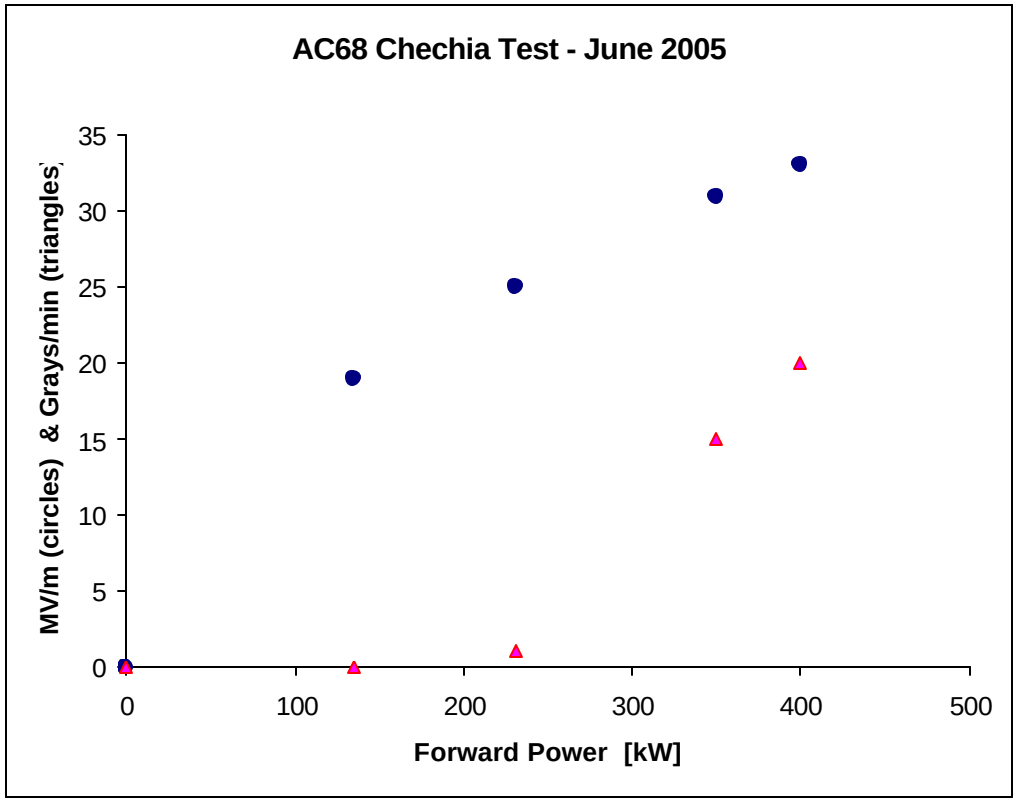
HP RF Testing At Desy: June



HOM Alignment

Horizontal Test Vessel

CC2 (AC68) Chechia Results



PEAK GRADIENT

33MV/m

20 Grays of X-rays

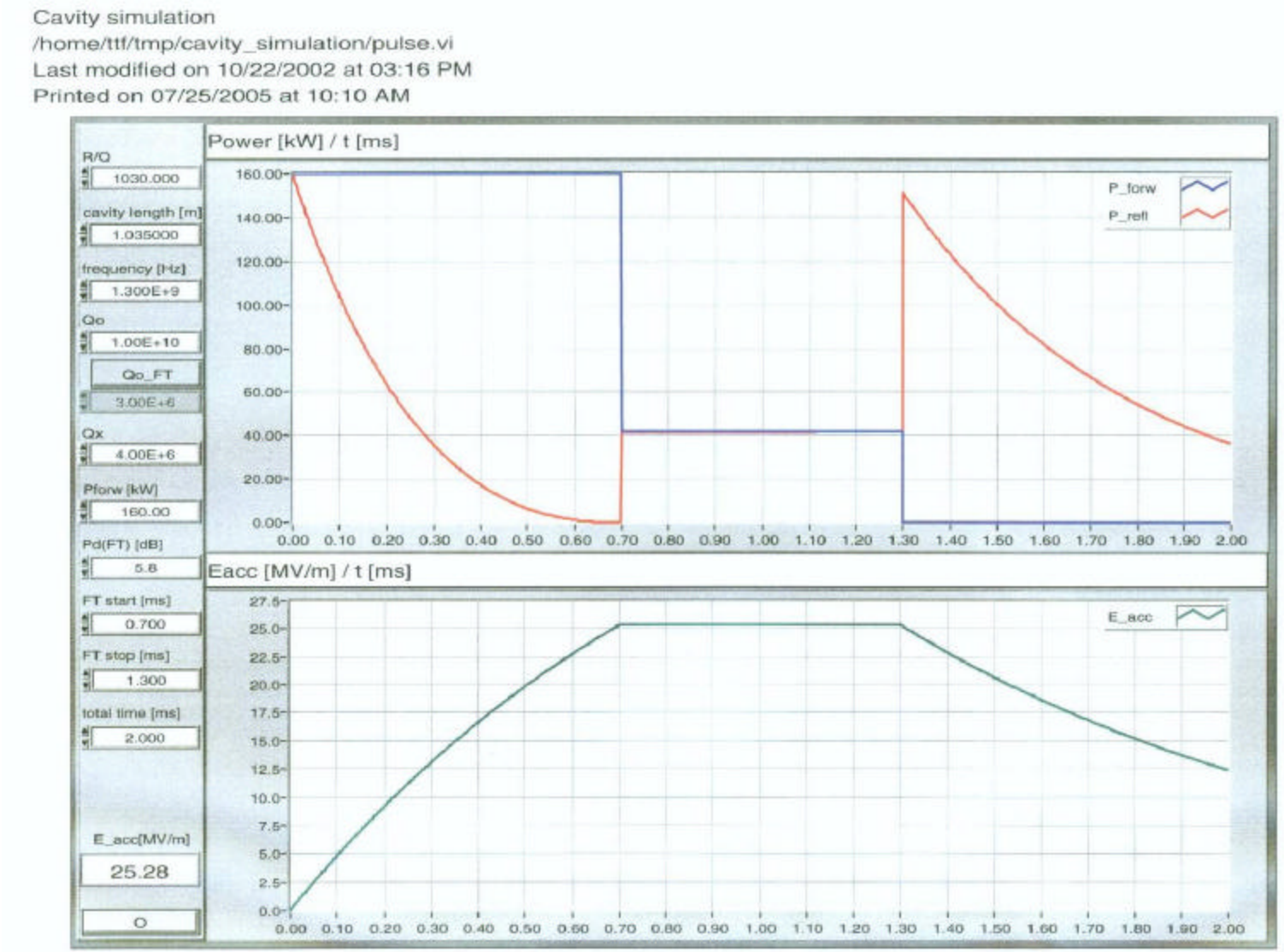
(2 Rad/min)

OPERATING GRADIENT

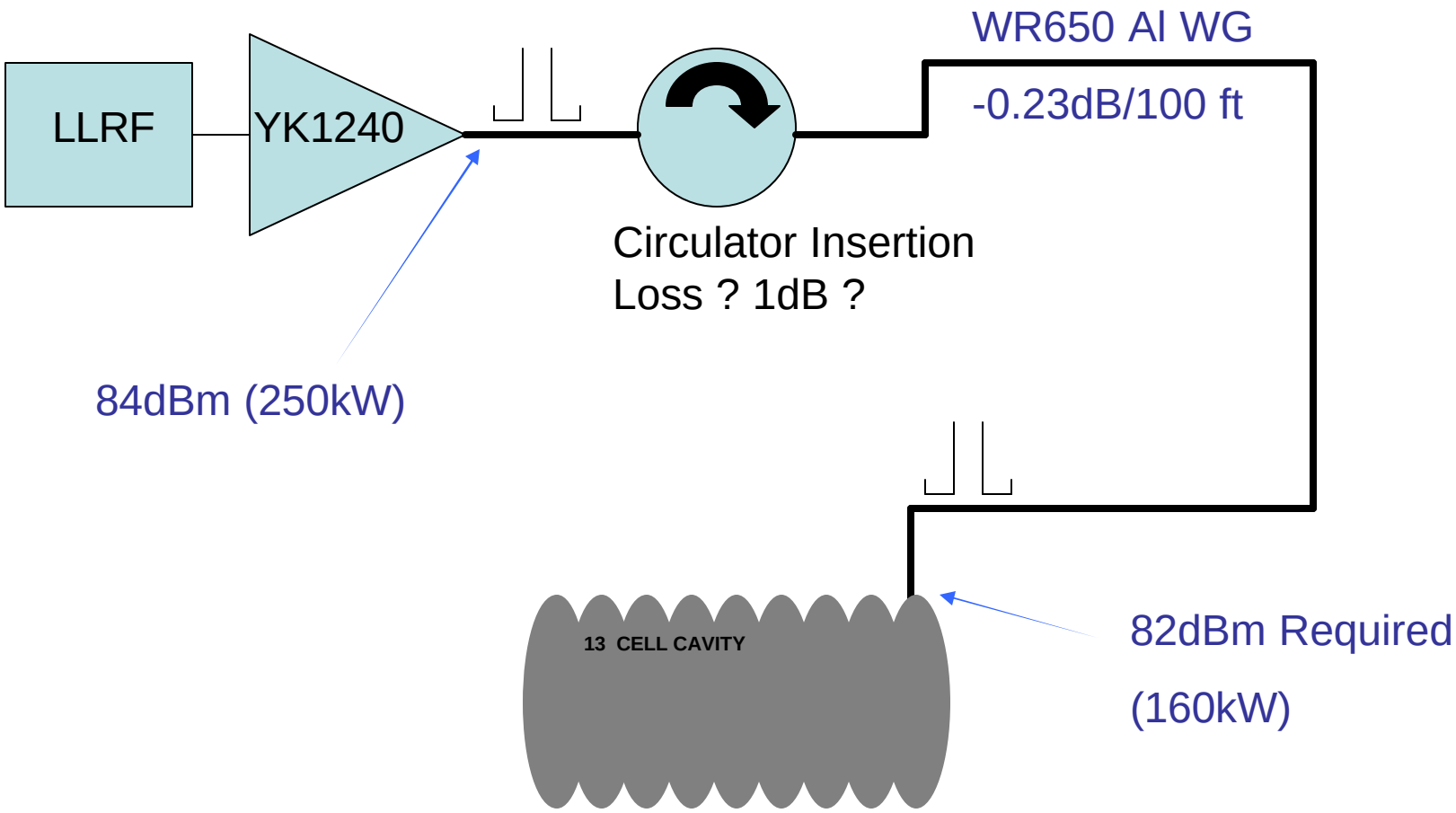
25MV/m

~ 1 Gy/min

Calc'd CC2 Power Requirements

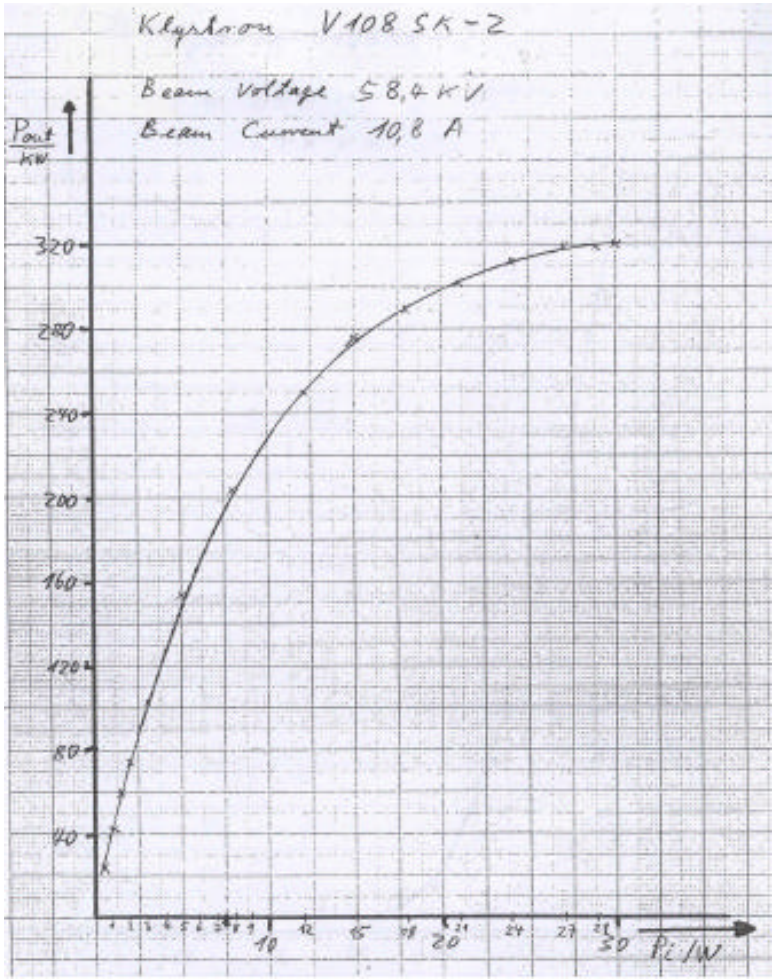


CC2 RF Map

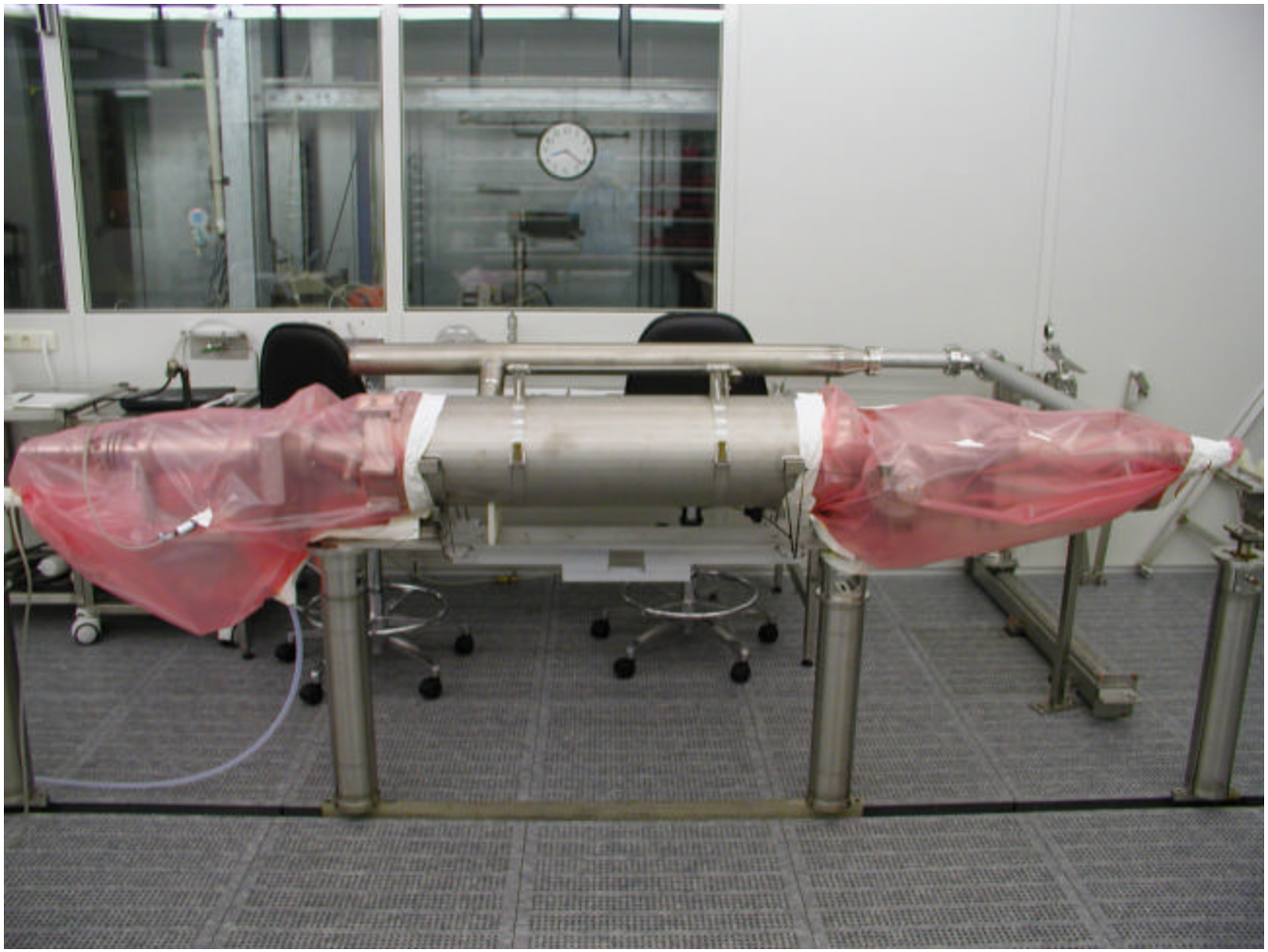

LLRF
YK1240
WR650 Al WG
-0.23dB/100 ft
Circulator Insertion
Loss ? 1dB ?
84dBm (250kW)
13 CELL CAVITY
82dBm Required
(160kW)

Calc'd CC2 Power Requirements

Need to test rebuilt YK-1240 tubes' performance



CC2 Preparation at DESY & FNAL



CC2 Preparation at DESY & FNAL

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CC2 Preparation at DESY & FNAL

STILL, A LONG LIST

Attach thermal straps.
Attach thermometry.
Modify liquid level can, and feedcan plumbing at throat.
Install feedcan plumbing at throat.
Fabricate and install quarter-moon supports beneath Cheecia plate.
Remove diving board supports and attach end caps.
Close both VAT valves.
Prep cryostat for transport to SMTF.
Transport to SMTF on air trailer.
Fabricate portable class 10 clean room and send to SMTF.
Fabricate vacuum pumping stations (with Faraday cup).
Bring cryostat into SMTF cave.
Attach vacuum pumping station supports.
Prep mirrored tuner (with piezo bracket) for installation and remove DS end cap (re-attach diving board supports).
Remove quarter-moon supports and Checcia plate.
Insert G-10 rod at bottom.
Install mirrored tuner using class 10 cleanroom.
Connect instrumentation to tuner and piezo and test.
Wrap tuner end with super-insulation.
Re-attach DS end cap.
Remove US end cap and re-attach diving board supports.
Move class 10 cleanroom to input coupler area.
Prep input coupler for installation.
Install input coupler under class 10 hood.
Wrap US end with super-insulation.
Remove diving board support and attach US end cap.
Connect pumping stations to (one or both ends) with VAT valves c losed.
Open both VAT valves.
Connect feedcan and all vacuum flanges.
Pumpdownvacuum vessel.
Pressure test helium vessel.

Shipping: lessons learned

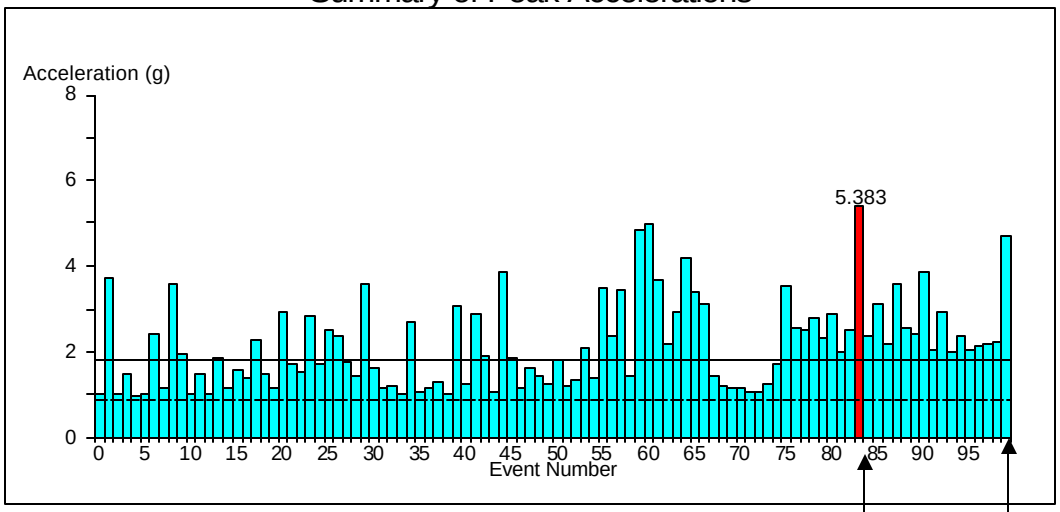
DO NOT SHIP WITH INPUT COUPLER ATTACHED

Shipping: lessons learned

100 Events (50 Warnings, 50 Alarms)

	Event	Axis	Date/time	Modulus (g)	Temp (°C)
First Alarm	1	Z	15/07/2005 16:59:48	3.72	30.3
First Warning	0	X	15/07/2005 16:55:13	1.01	30.5
Most Severe	83	Z	26/07/2005 14:27:10	5.38	24.9

Summary of Peak Accelerations

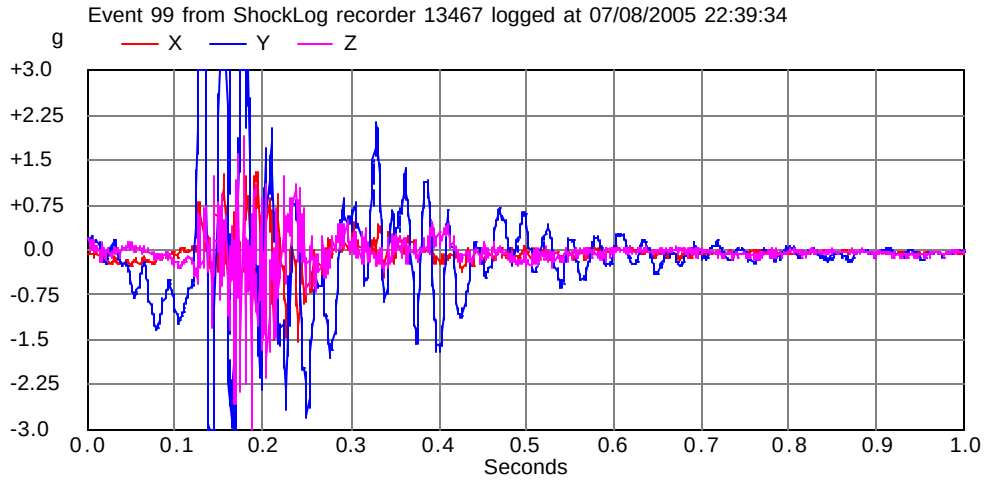


Cavity AC68 loaded just <u>after</u> worst event

Cavity AC68 arrives at FNAL

Worst Event was a Kick

Worst Event: 2:30PM

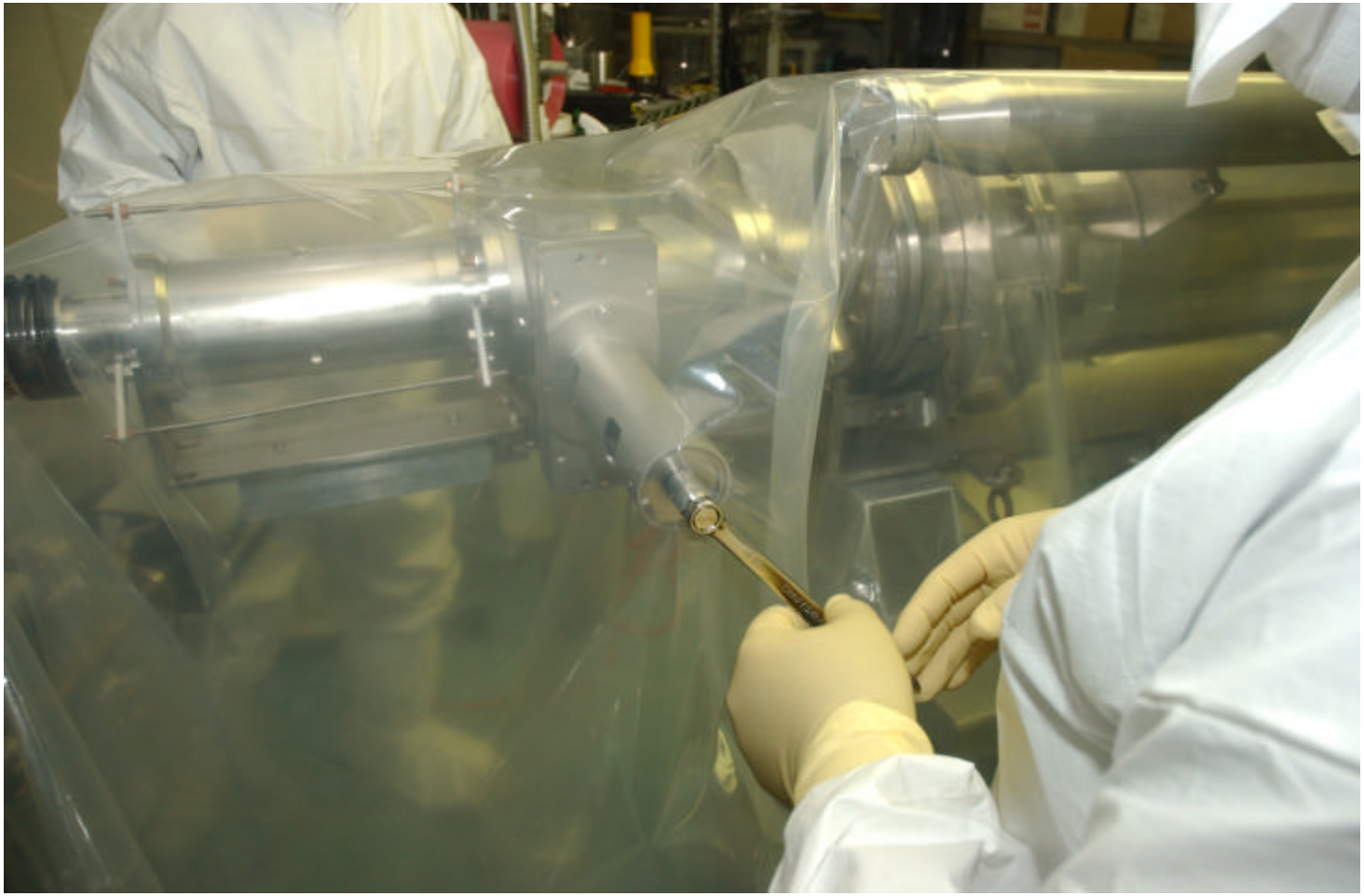


The worst event was identified to have happened before the cavity was installed by about 1 hour.

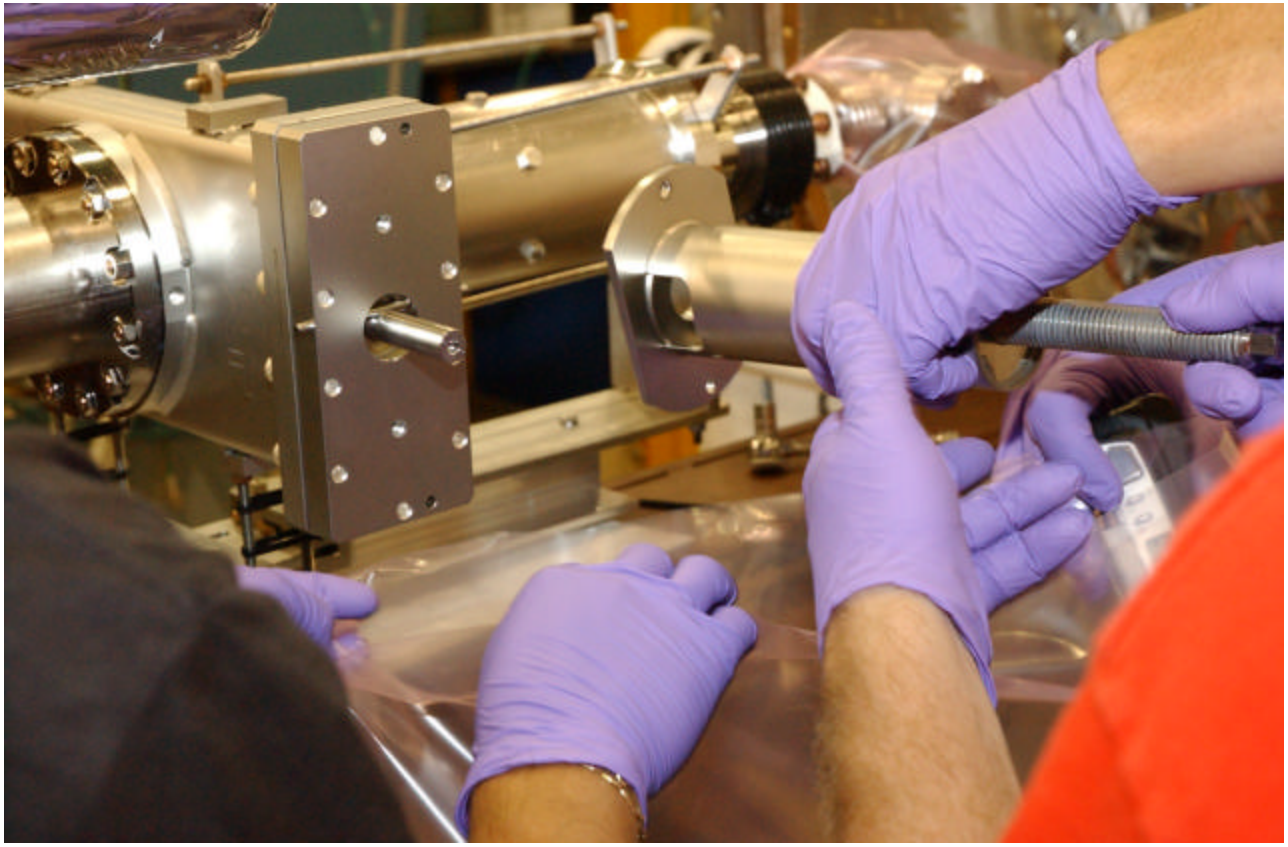
Possible Second Worst Event:
(this time with the cavity)

Puncture in crate noted upon arrival at FNAL

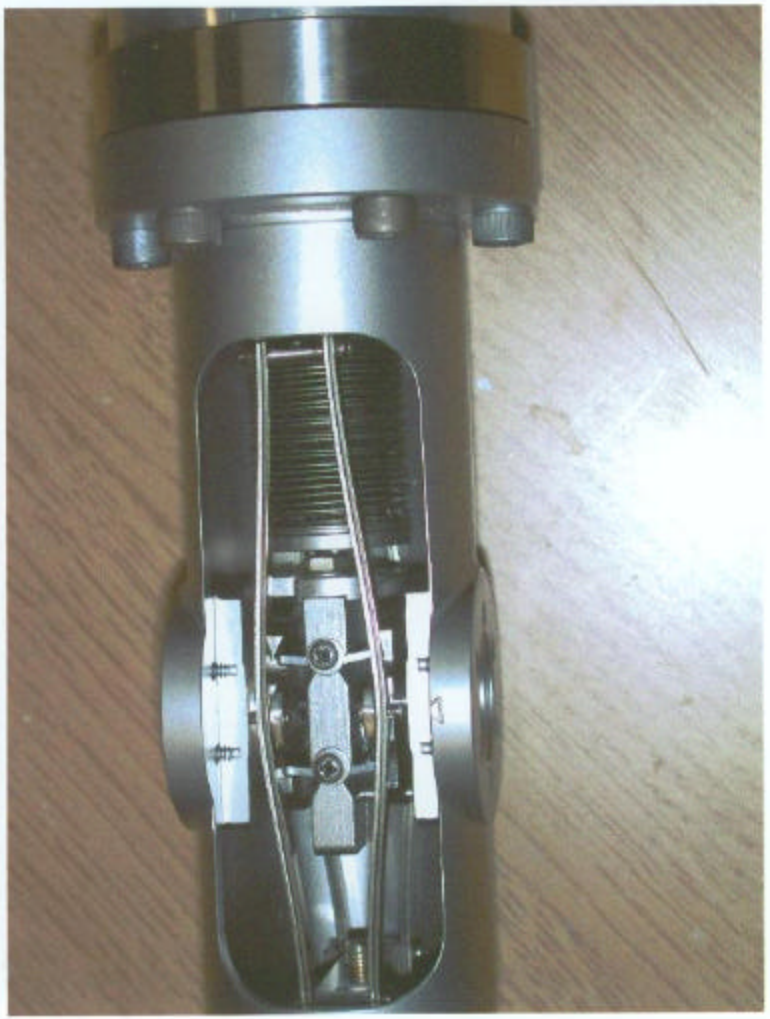
VAT Valve Crisis of 2005



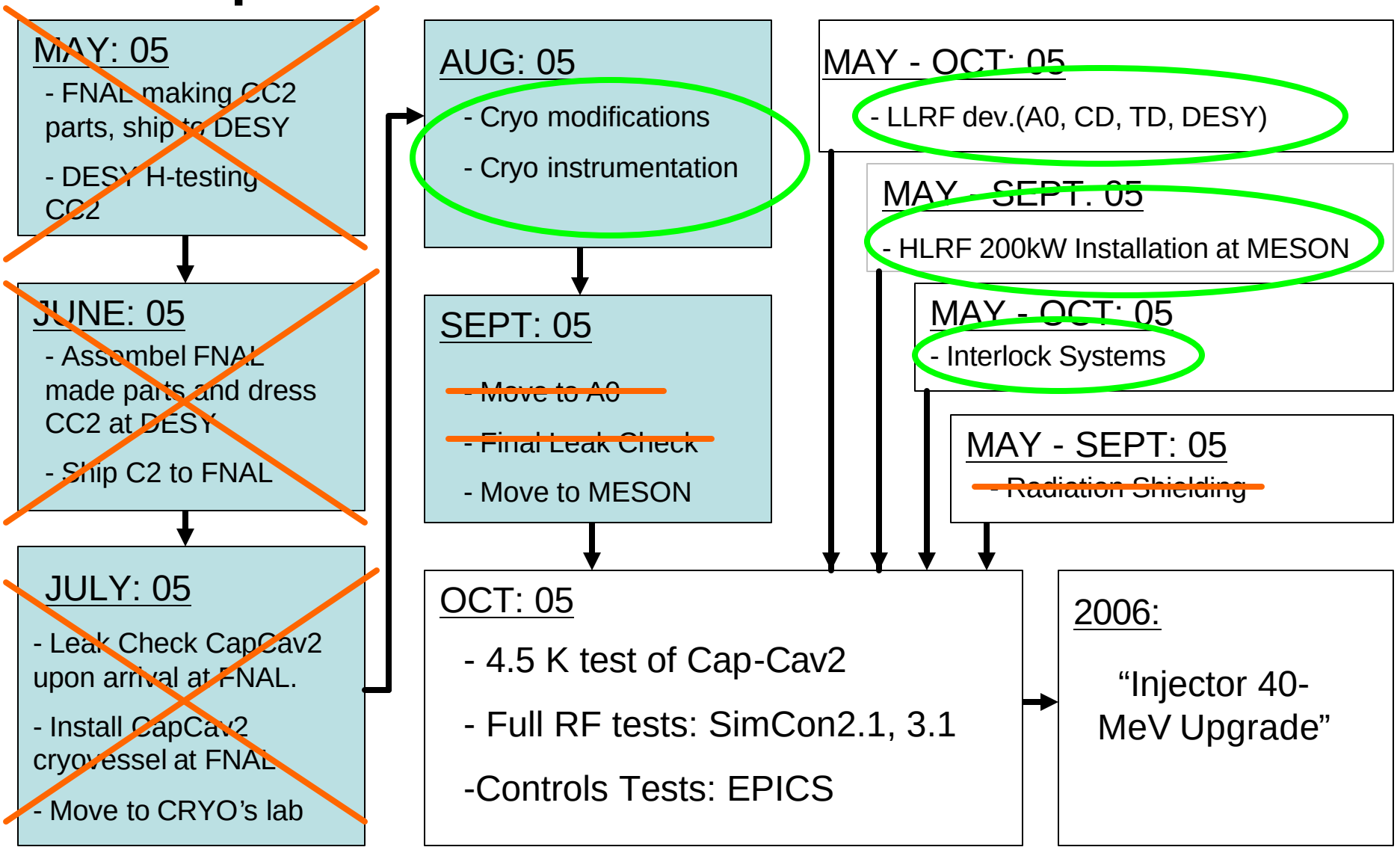
VAT Valve Crisis of 2005



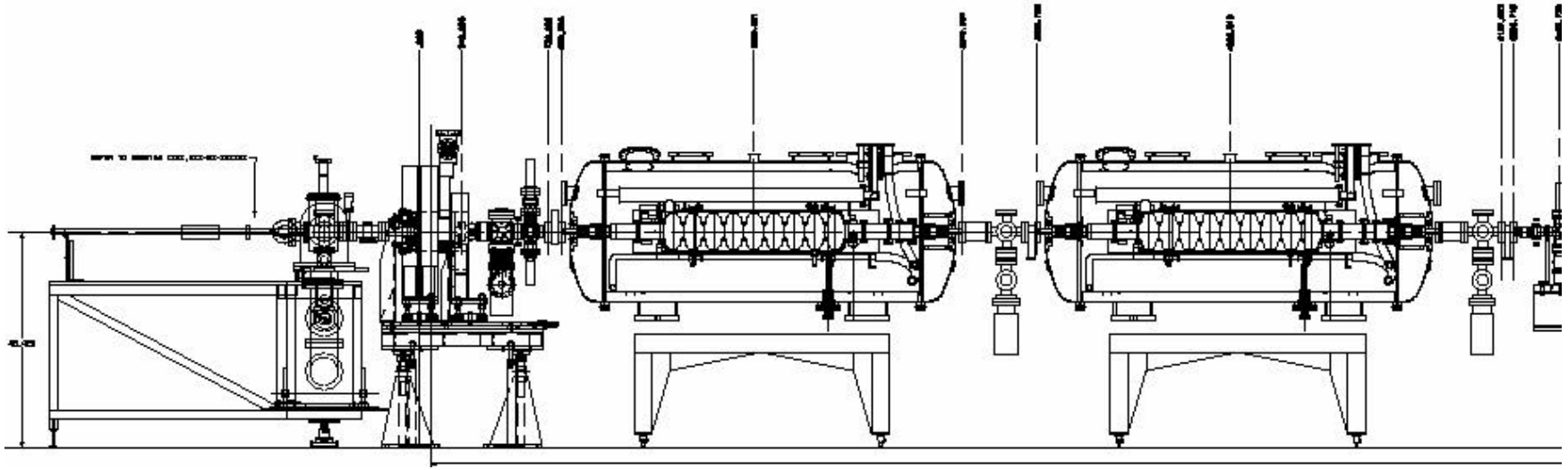
VAT Valve Crisis of 2005



CapCav-2 Parallel Time Lines



The Future:
Photo Injector 40 MeV Upgrade



$$F_{\perp} \propto \frac{1}{g^{2}}$$

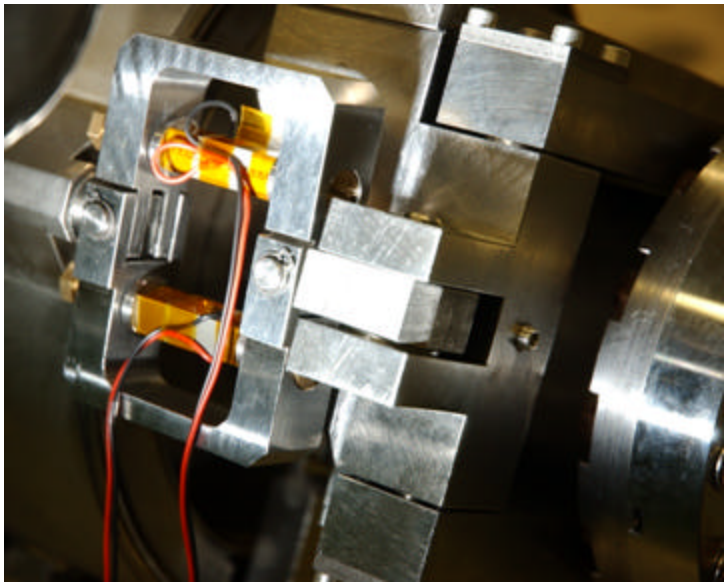
?2 At 15 MeV = 900
?2 At 45 MeV = 7755

The Future:
Some tough questions:

- What is the exact upgrade plan ?
- When do we do the upgrade ?
- Where do we do the upgrade ?
- Who does the upgrade ?
- When do I graduate ?

The Future: Fast Tuner Studies

- Piezo Electric Actuators:

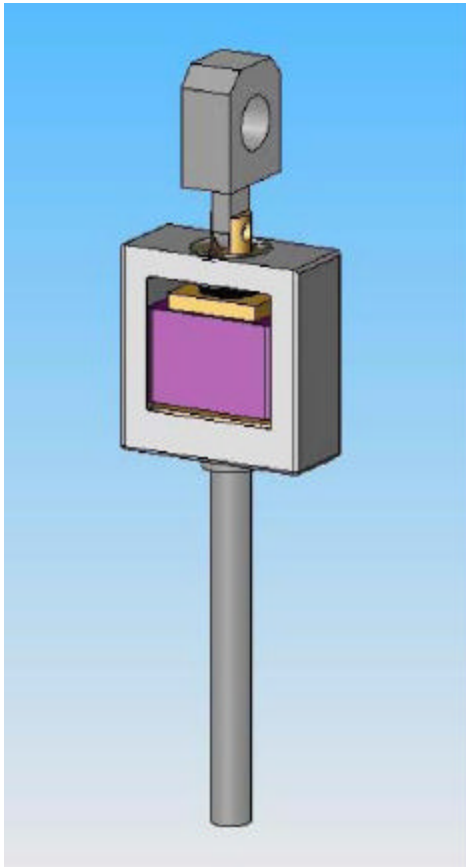


1st a thorough Mech-Eng'g study of a single element piezo actuator in CC2 this October.

Ruben, Salman, Cosmore, Mike

Et.al.

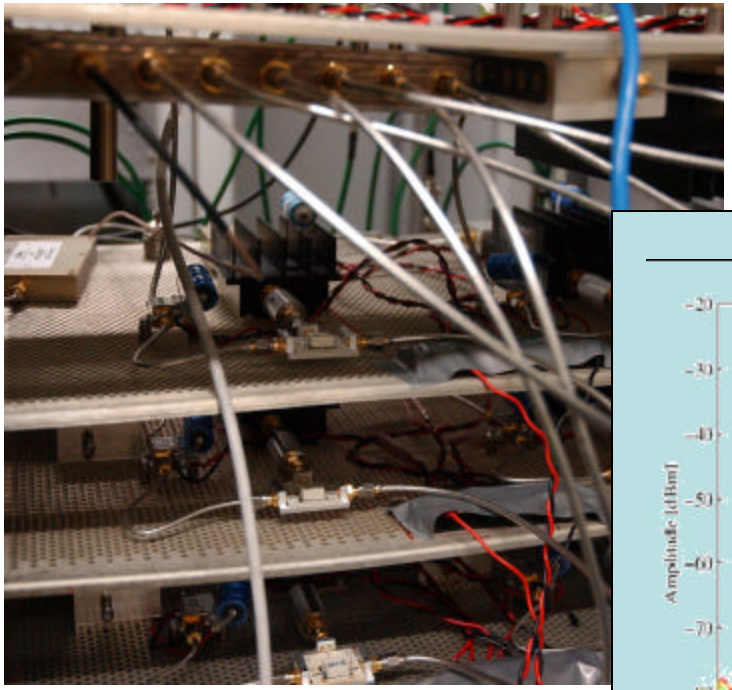
- Magneto Restrictive Actuators:



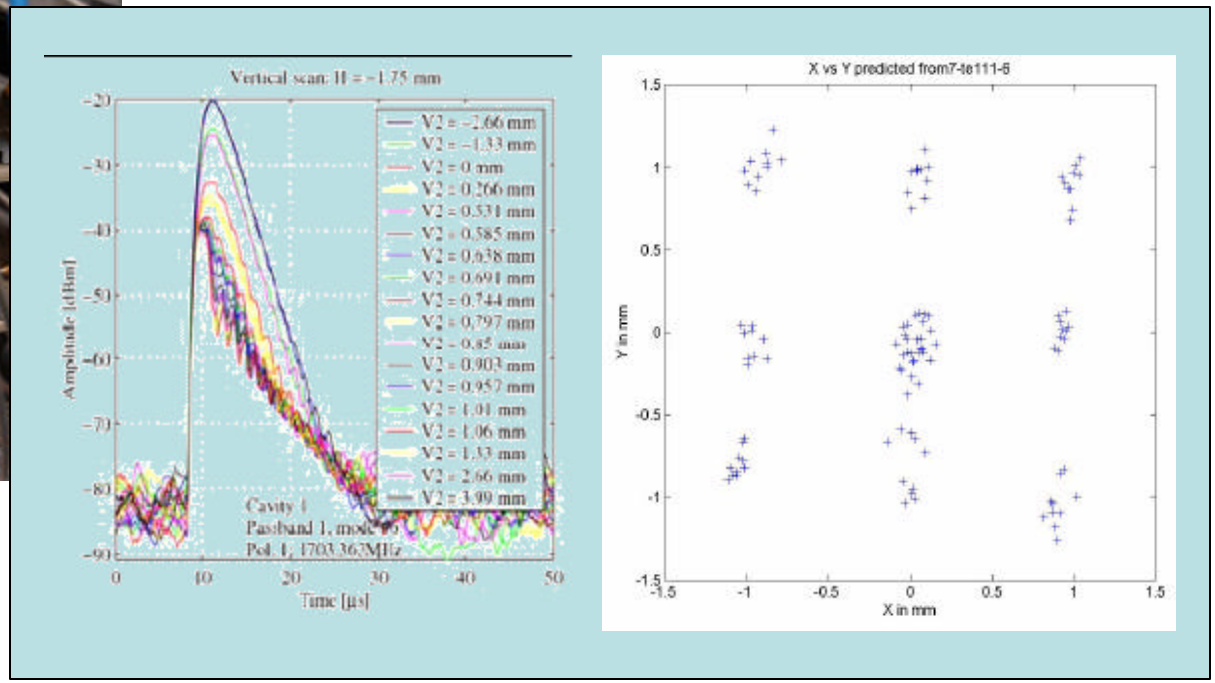
FNAL has one on order from Energen, and will be testing will CC2 soon !

The Future: p in the Sky: CC1 & CC2 HOM Alignments

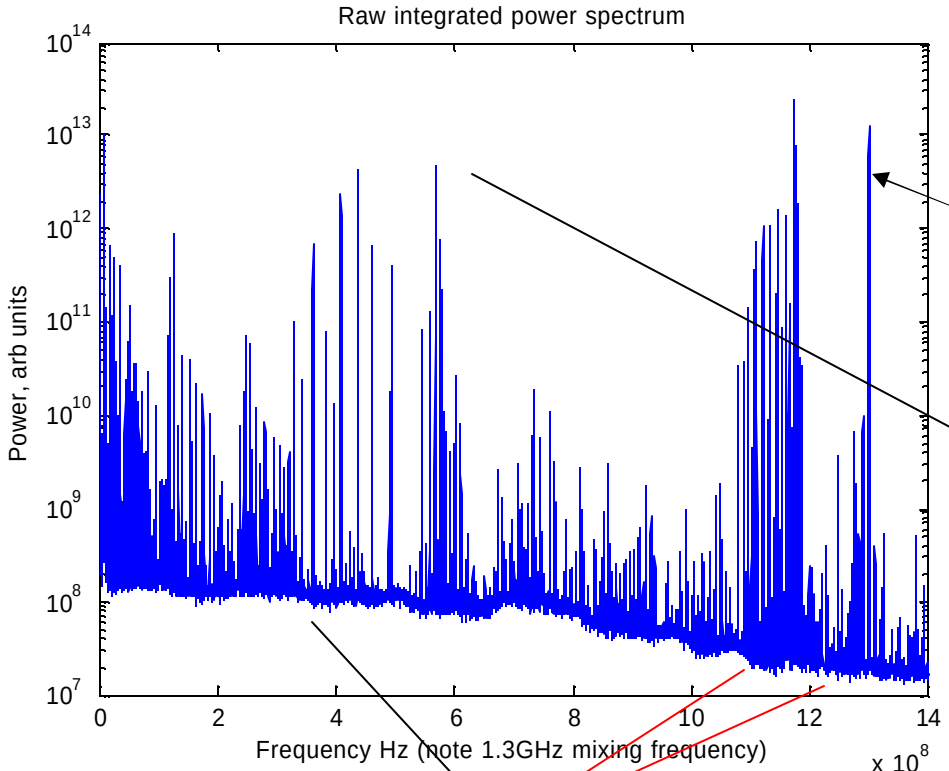
Cavity alignment has been measured to an accuracy of ~5µm, but never has a cavity been aligned by HOMs. I would like to try.



Data Taken from HOM run at DESY in April



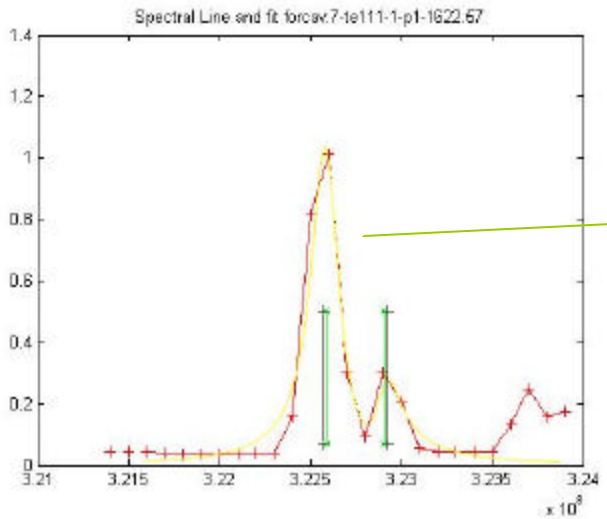
HOM Spectrum

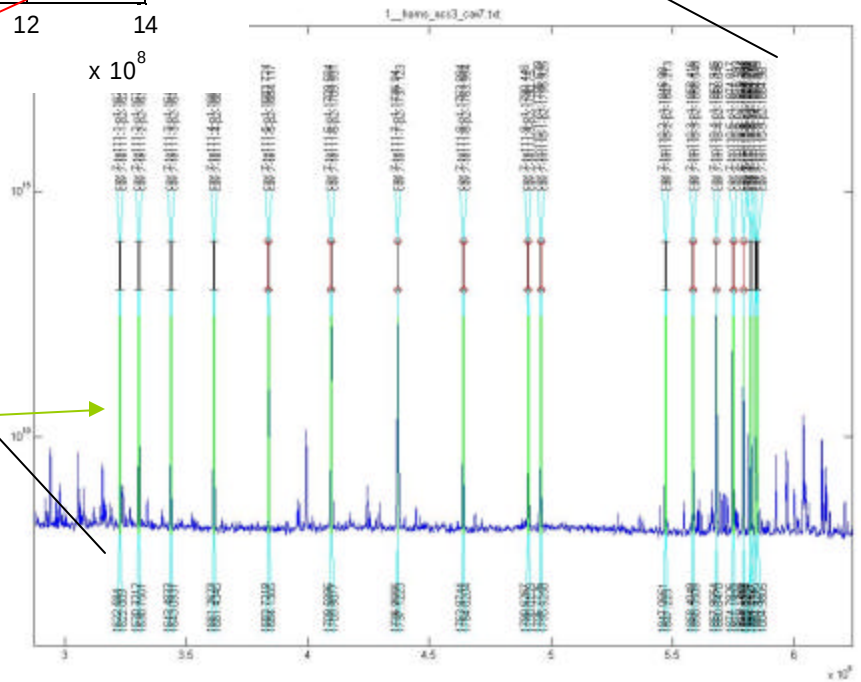


1.3GHz reference line

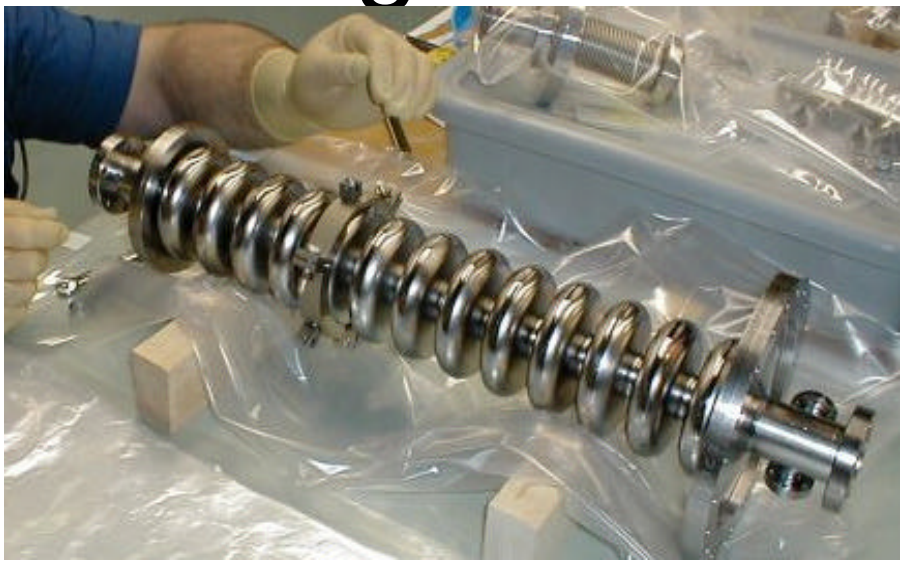
Dipole Band 1,2

Monopole modes



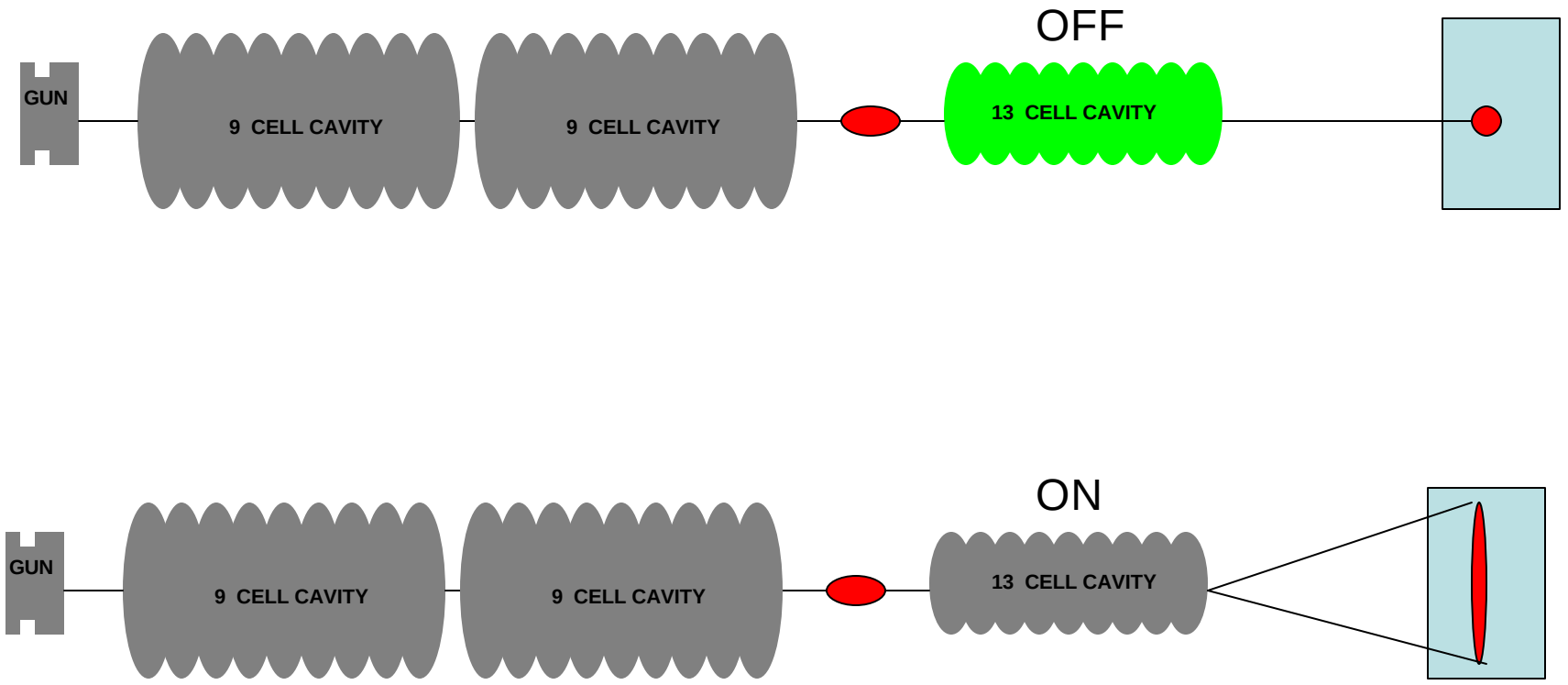


Deflecting Mode Cavity

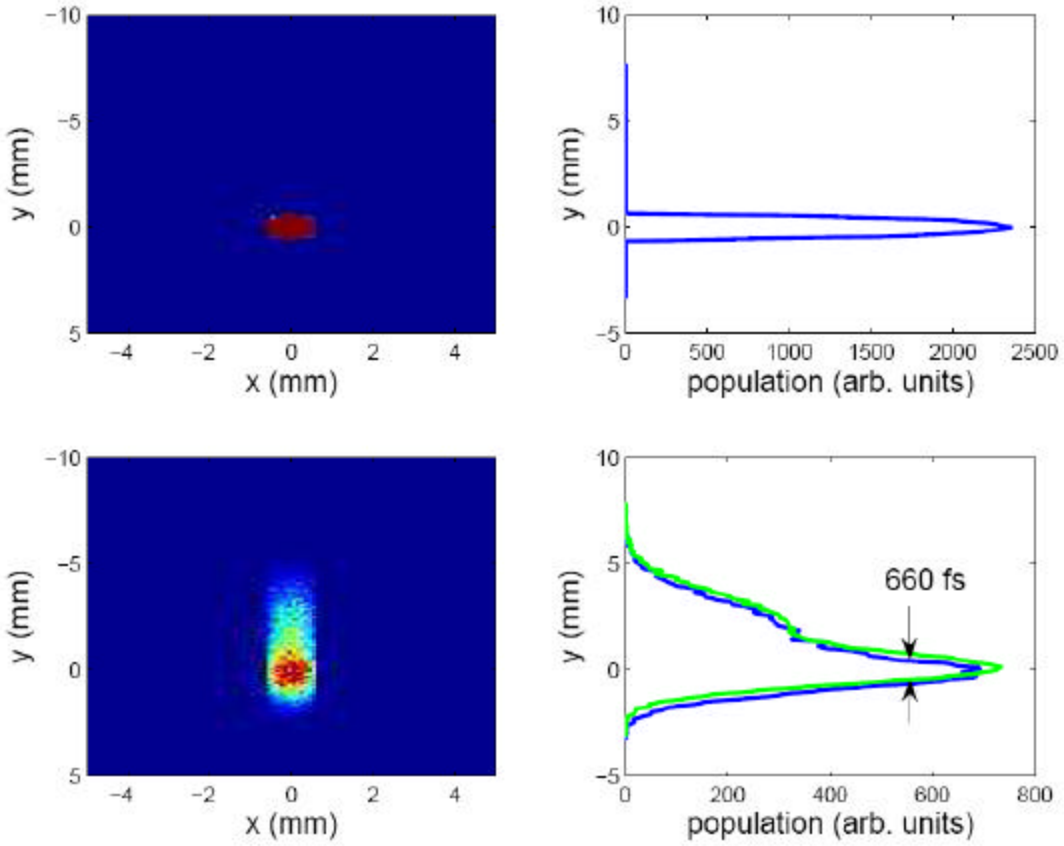


- CKM TM_{110} mode cavity was developed for a fix target beam line optical element
- CKM is gone, however, the cavity has found life in other applications

The Deflecting Mode Cavity as a bunch length diagnostic



The Deflecting Mode Cavity as a bunch length diagnostic



20 fs resolution !

Other DMC use & test beam

- Ideal for ILC Crab Cavity !
  - 3.9 GHz exact multiple of ILC
  - LOM antenna may be a problem
- ANL's APS is also interested
  - Blow up in transverse
  - Undo, returning bunch to small transverse dim
  - Large duty factor may not be compatible w/ HOMs
- Photoinjector is needed for a test beam.

The Future: LLRF Studies

Low Level RF studies encompasses R&D on the signal conditioning that drives the power amplifiers of the cavities. The conditioning occurs via:

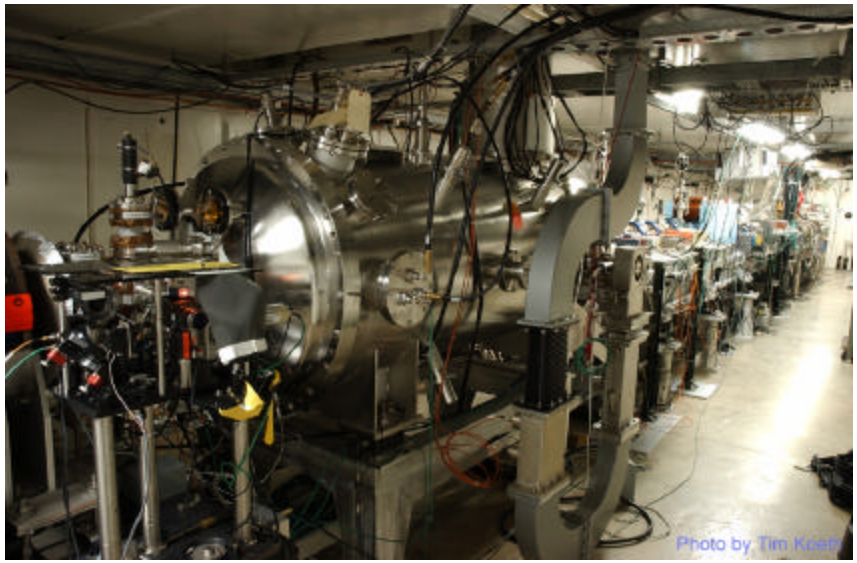
- Algorithms that control the Frequency, Phase and Amplitude to compensate for Lorentz force detuning, beam loading, microphonics, vector-sum optimization, etc

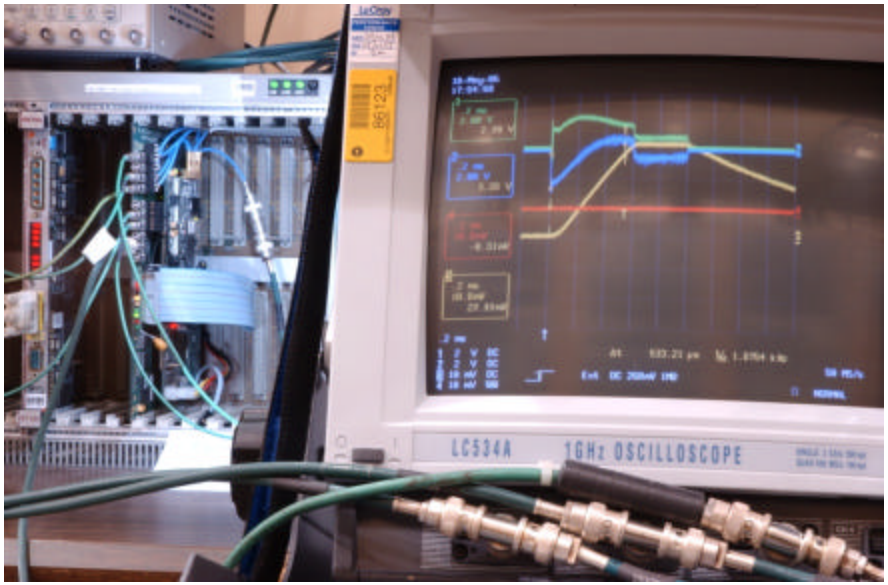
- A serious LLRF program needs to fired up ! A small effort is underway, mostly from people in the CD and TD. A0 imediately offers a test bed for LLRF developement. Even DESY has needed A0 to test their LLRF systems.

LLRF Studies: Distant collaborators

- A0 has been used for development and testing of DESY's SimCon 2.1 hardware, as well as different algorithms run on SimCon 2.1 that were developed by Warsaw and DESY.
- Remote control of the SimCon2.1 from Warsaw and DESY have both been successfully accompolished

CapCav-2: LLRF





CCII LLRF Prep Tests at the FNPL A0P1:

March 2005

Established closed loop control of Fermilab's A0 9-cell Superconducting cavity.

May 2005

Established remote control of SimCon setup at Fermilab

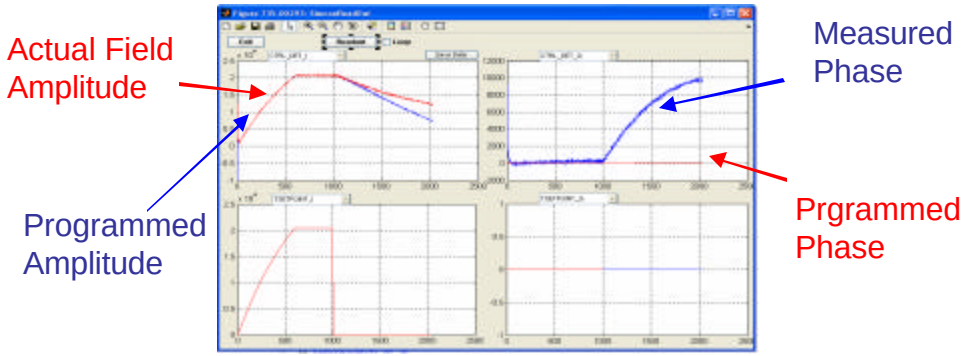
May 2005

DESY's remote control of 9-cell system.
Closed loop remote control.
Complete system calibration.
Testing of Warsaw & DESY feed back algorithims

Sept 2005

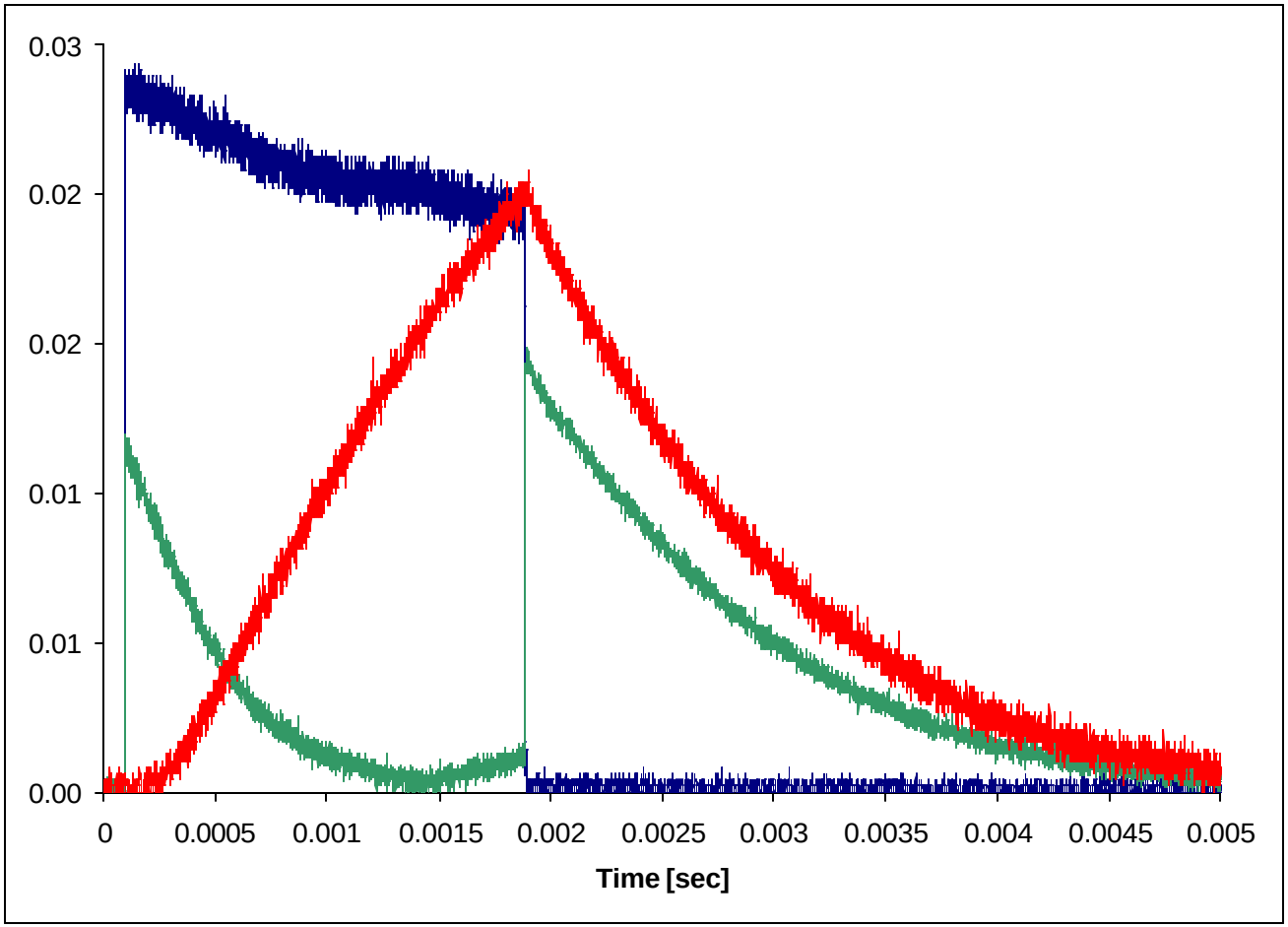
Tim, Ruben, Darryl, Roger, Ron, Andrejz etc installed and ran SimCon2.1 S/N: 2 ! (on our own)

1st Display of SimCon2.1.0 closed loop control. A0, March 2005



Taken just yesterday on CC1

FWD POWER RFL POWER TRANS POWER



LLRF: FNAL Algorithm R&D

- In addition to DESY use of SimCon2.1, FNAL engineers have built up several more SimCon2.1 systems in order to study the algorithms.
- We have promise of a Grad Student proficient in FPGA programming: Arthur Payton. Arrives

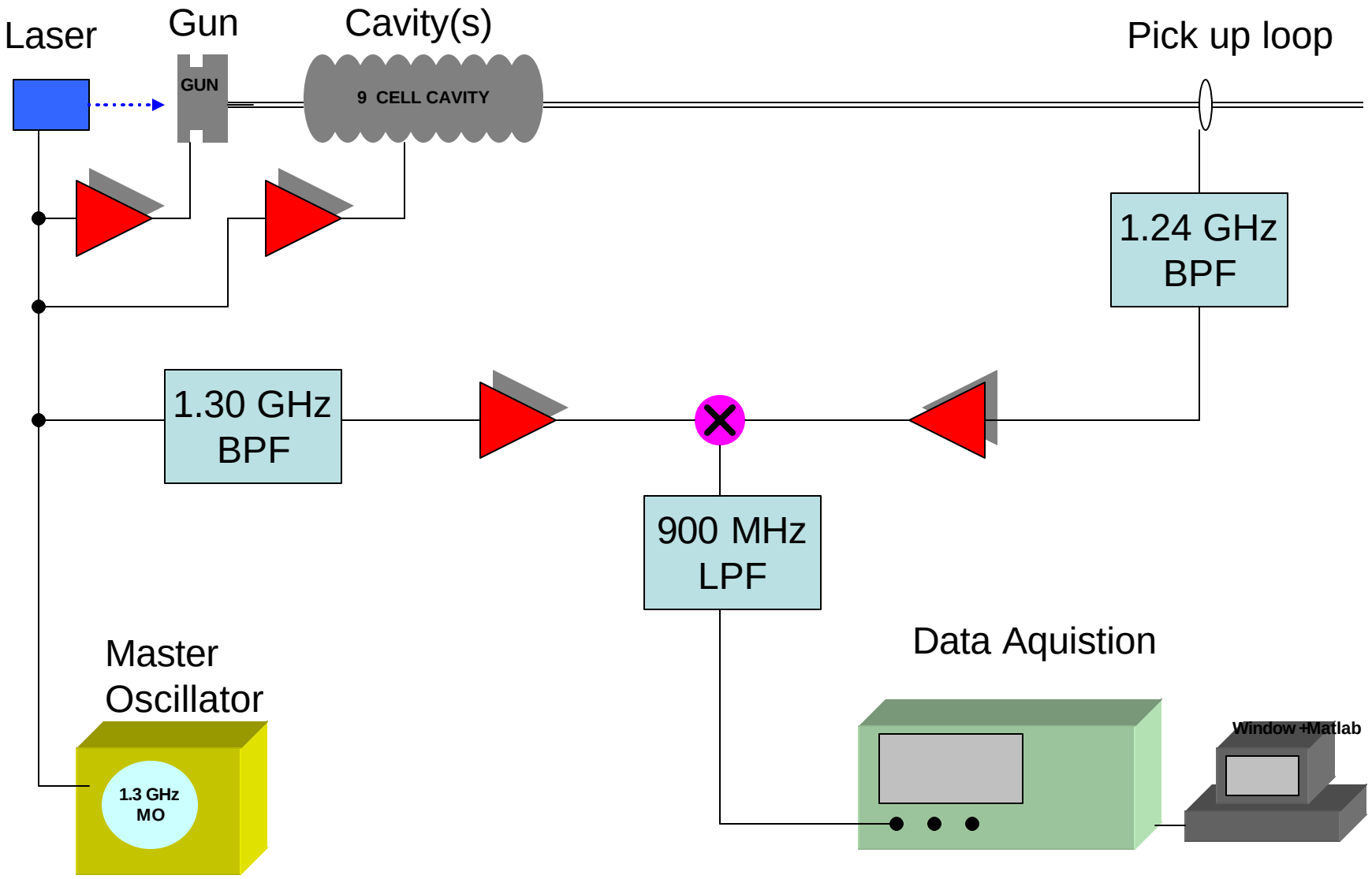
Arthur's Proposed Thesis Topic

Development of FPGA-based low level control system for superconducting radio-frequency cavities Superconducting radio-frequency (rf) cavities such as the one as needed for the international linear collider (ILC) [1] require precise control of field amplitude and phase during the long (1 ms) RF pulses being used to accelerate the train of bunches. Currently the cavity fields are controlled with digital signal processing (DSP) chips. Such chips have a limited number of possible operations per cycle and prevent certain algorithms to be implemented [2]. Recent advances in the performance of the Field Programmable Gate Arrays (FPGA) have open new path for developing faster low level rf control system. Prototypes of FPGA-based control systems are being developed at DESY [3] and Fermilab. The PhD candidate will be working in collaboration with DESY and Fermilab personal on developing and implementing new algorithms (feed-forward, adaptive feed-forward, vector sum calculations, feedback, compensation of cavity detuning during the rf-pulse, etc...) to control the rf cavity using FPGAs as low level control system and DOOCS or EPICS for high level applications. The algorithms could then be directly tested, with beam, at the Fermilab/NICADD photoinjector laboratory [4] where a TESLA-type superconducting cavity is operated. The work of the PhD candidate is expected to have a major impact on the design and prototyping of the rf control system for the superconducting module and test facility (SM&TF) [5]. SMTF is a planned test facility for the ILC proposal that will be built at Fermilab.

Miscellaneous

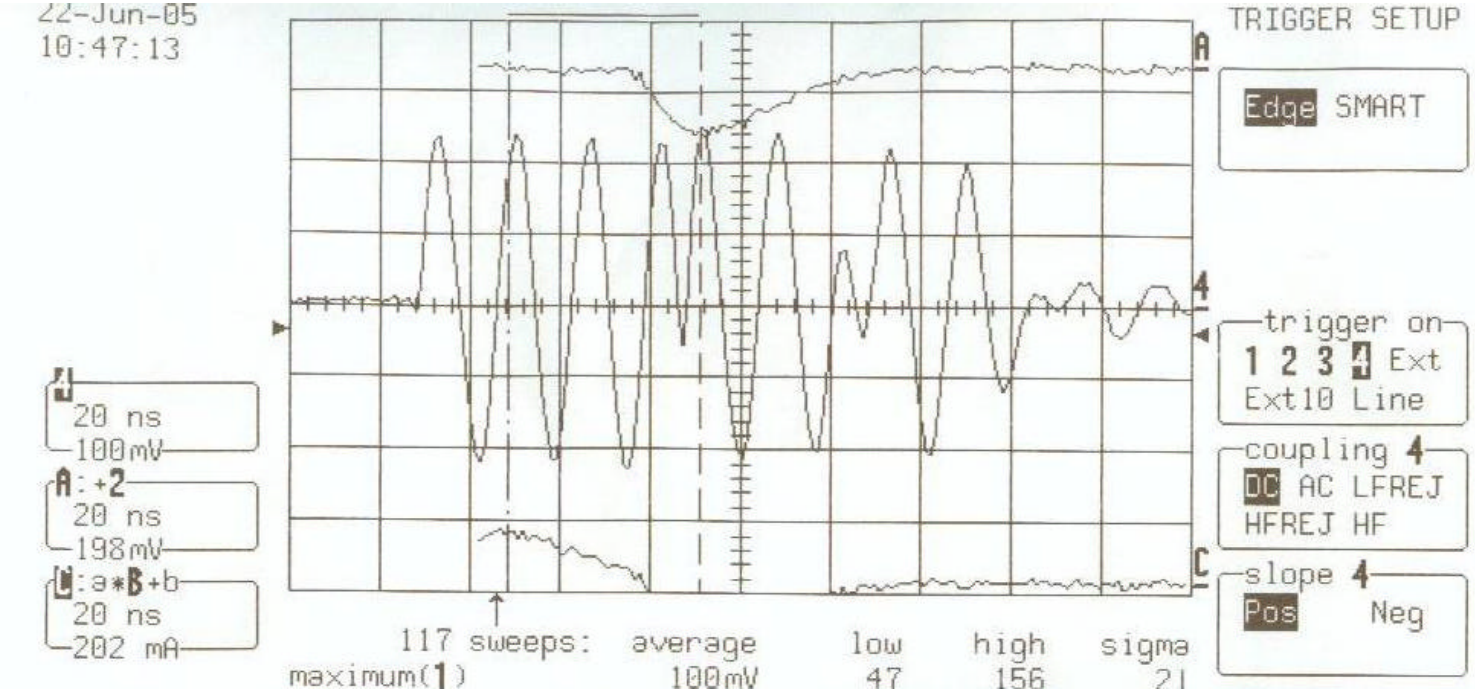
TOF Phase Measurement

Longitudinal characterization



TOF Phase Measurement

First Beam Induced Signal from Phase monitor:



- Initial measurements provided 100 pSec resolution.
- ~ 1ps resolution desired.
- I need to understand the system better.

TIME LINE

Tim's Anticipated Thesis Time Line